Status of undulator development at RAL

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for RAL Group

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Scope

- R&D phase results
- 4-m module status
- Undulator module future (discussion)
- Summary

Development of superconducting helical undulators at RAL

- UK HeLiCal Collaboration is working on the development of the ILC positron source.

- Team at STFC Rutherford Appleton Laboratory (RAL) is running an R&D programme on superconducting short-period helical undulators.

- Members of RAL team are:
Elwyn Baynham, Tom Bradshaw, Amanda Brummitt, Steve Carr, Yury Ivanyushenkov, Andy Lintern and Jim Rochford.

- The RAL team has completed technological phase of the programme which enabled the construction of the first full scale 4-m long undulator module.

R&D phase results

- 5 short prototypes (see prototypes matrix) have been built and tested
- Questions addressed and answered:

- Former manufacture technique
- Undulator continuous winding technique
- Undulator resin impregnation
- Achievable field
- Effect of mechanical tolerances
- Undulator training and quenches
- Undulator measuring techniques

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Matrix of built and tested prototypes

	I	II	III	IV	V	V'
Prototype goal	Winding technique verification	Check effect of mechanical tolerances	Prototype with reduced period	Check effect of iron	Prototype with final period	Quench study with improved impregnation
Length, mm	300	300	300	300	500	500
Former material	Al	Al	Al	Iron	Iron	Iron
Winding period, mm	14	14	12	12	11.5	11.5
Winding bore, mm	6	6	6.35	6.35	6.35	6.35
Vacuum bore, mm	4	4	4.5	4.5	5.23	5.23
Winding	8-wire ribbon, 8 layers	9-wire ribbon, 8 layers	7-wire ribbon, 8 layers	7-wire ribbon, 8 layers	7-wire ribbon, 8 layers	7-wire ribbon, 8 layers
Sc wire	Cu:Sc 1.35:1	Cu:Sc 1.35:1	Cu:Sc 1.35:1	Cu:Sc 1.35:1	Cu:Sc 0.9:1	Cu:Sc 0.9:1
Field at test current, T	0.8	0.9	0.53	0.96	0.82	-
Test current, A	220	220	200	200	200	-
Quench current, A	-	-	-	-	230	315

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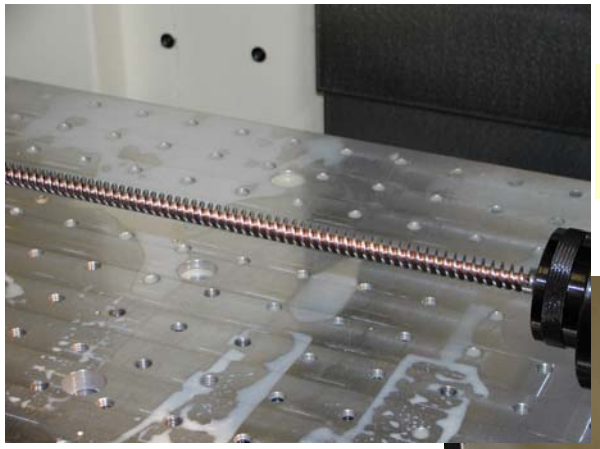
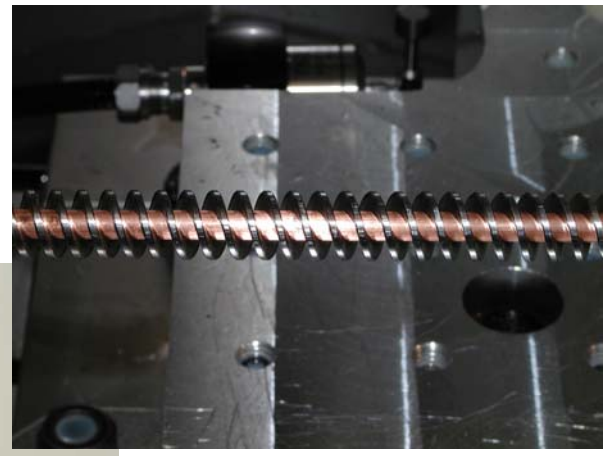
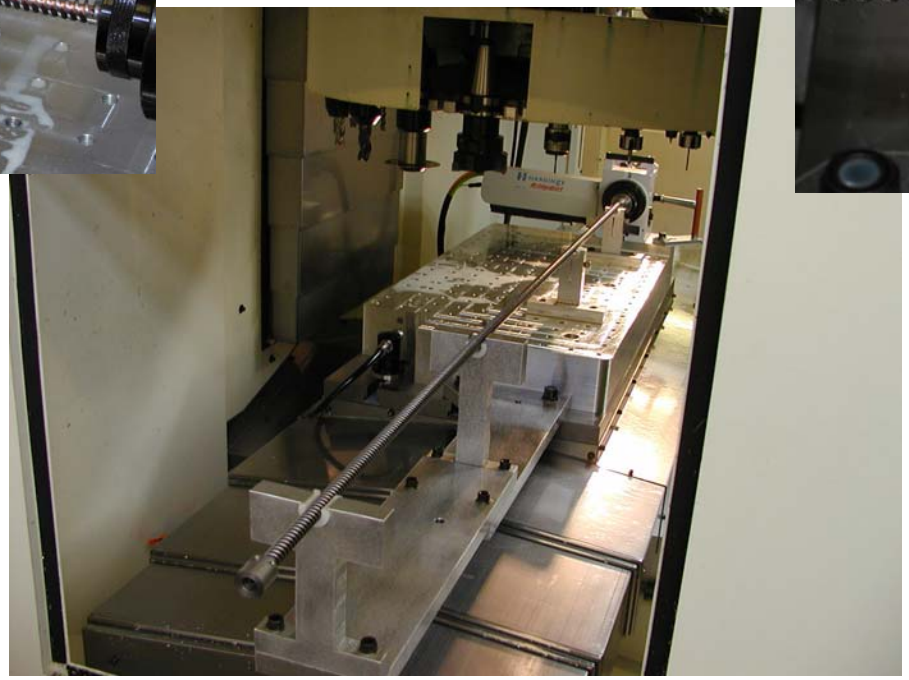
Former machining



Machining a 2-m long former





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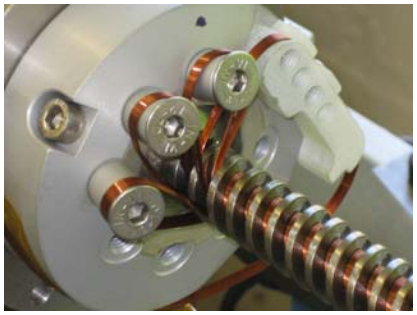
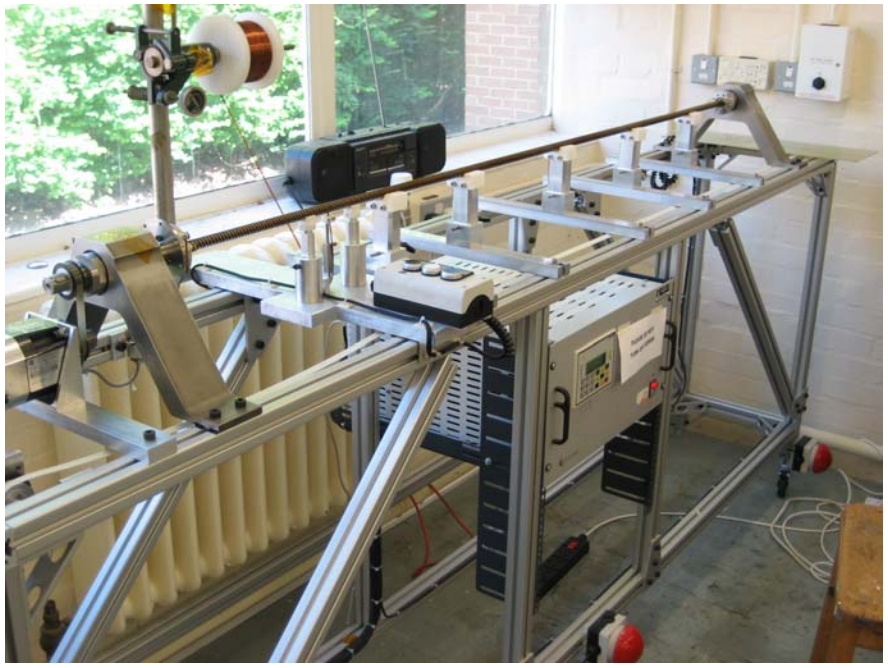
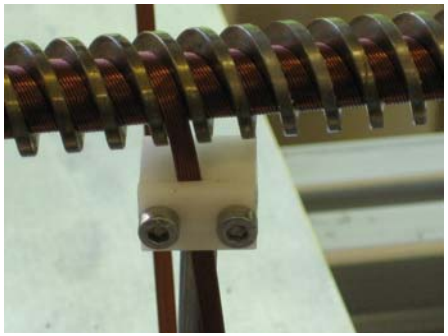
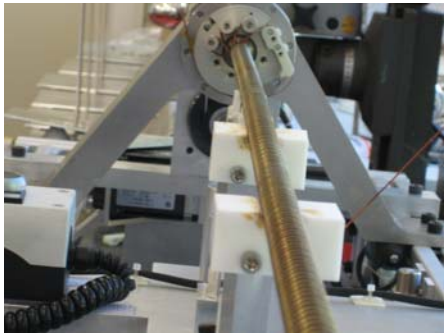
Undulator winding

Winding undulator on a custom built winding machine









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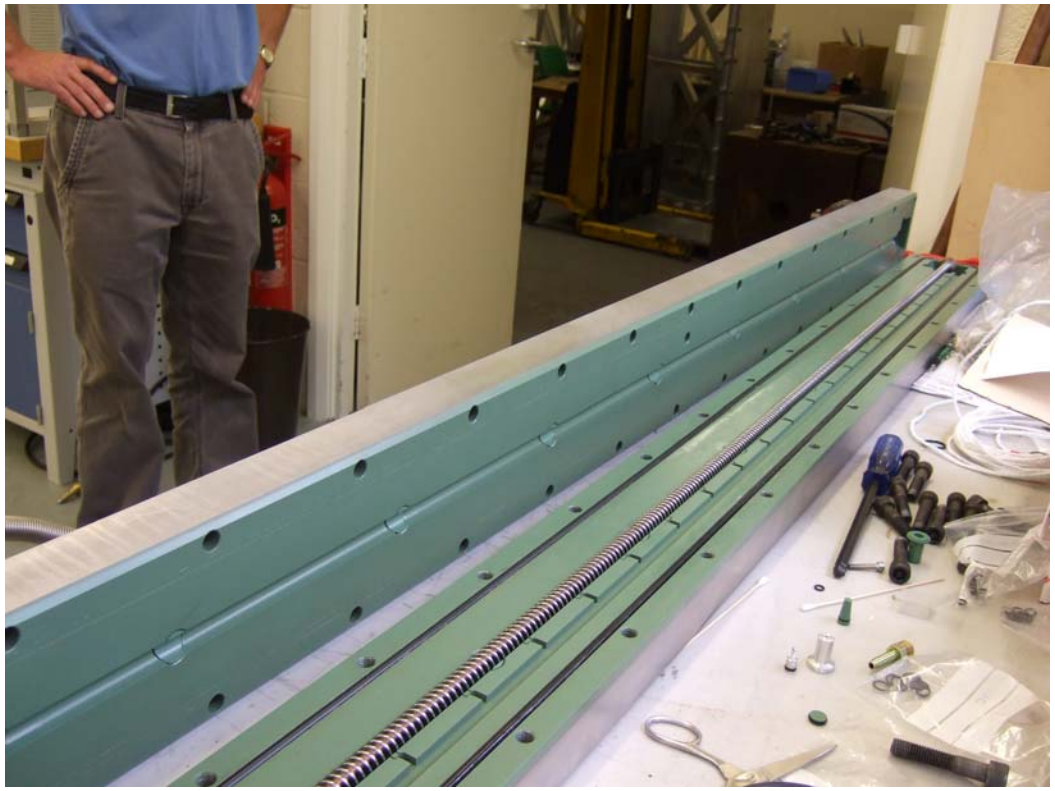
Undulator resin impregnation

Potting jig used for vacuum impregnation



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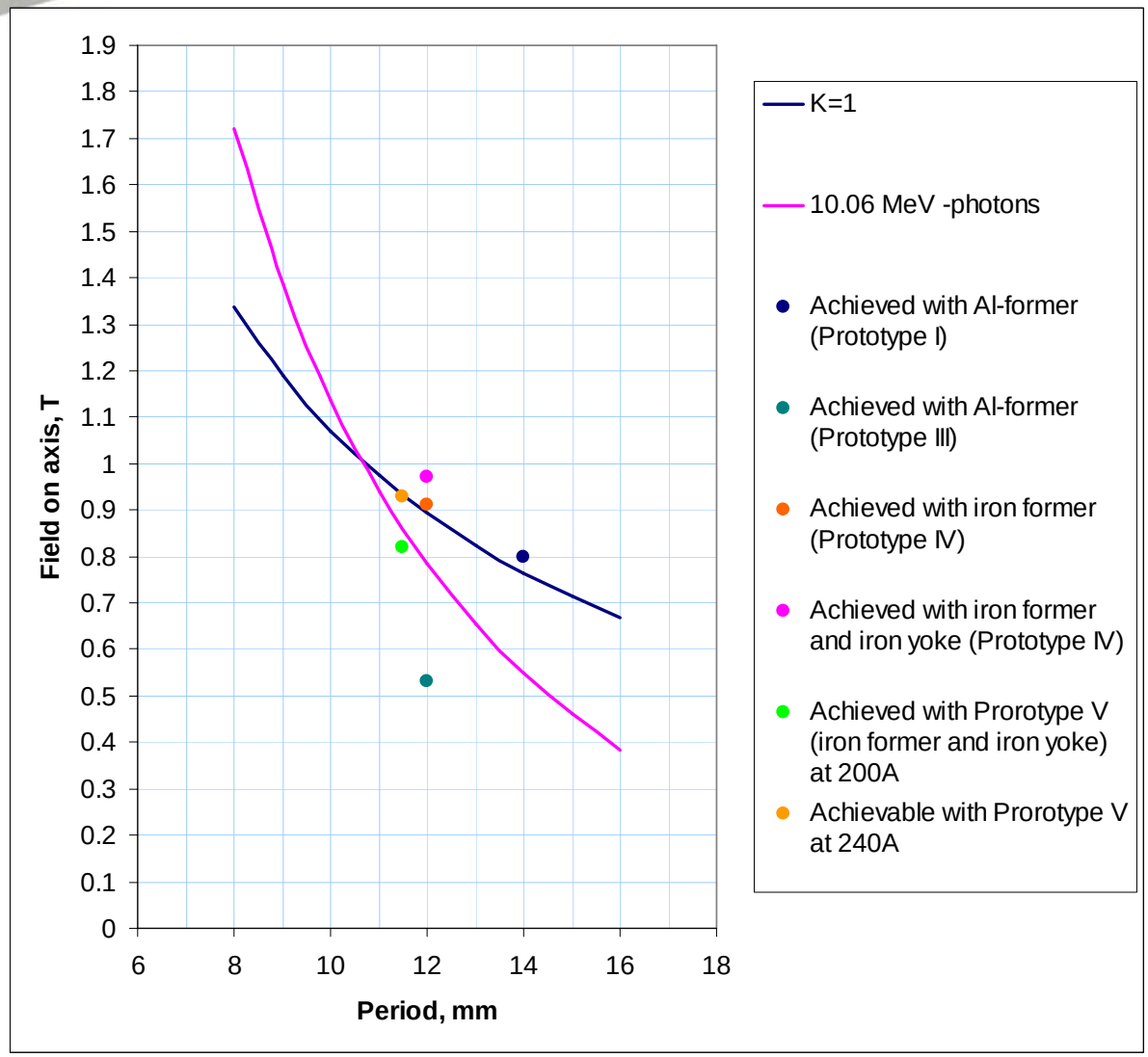
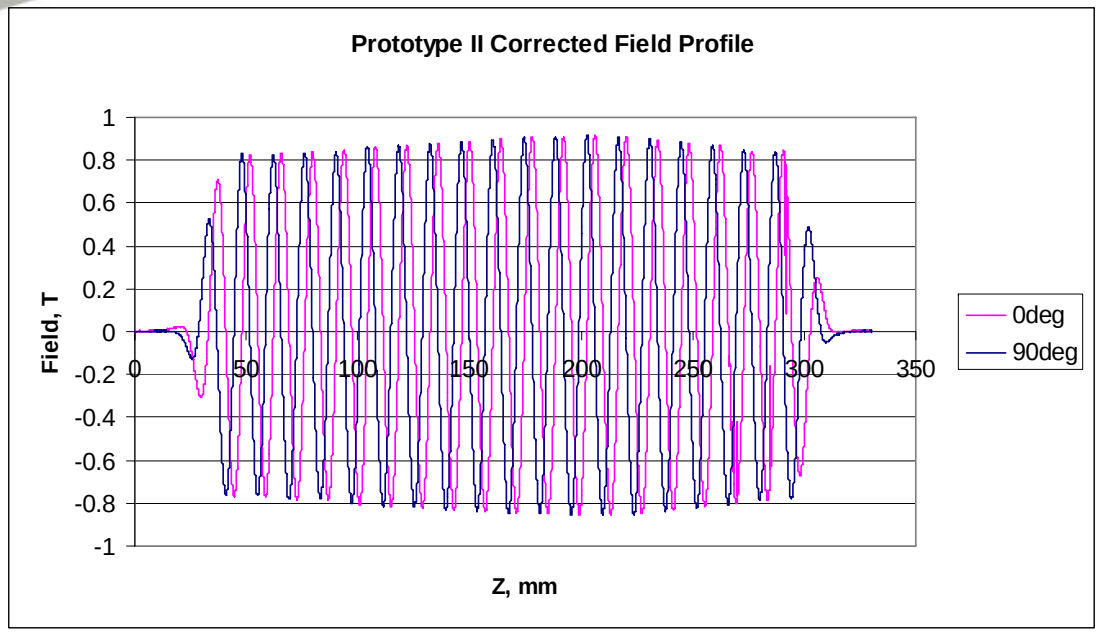
Field achieved with prototypes



R&D conclusion: the field required for the ILC undulator (RDR specification) is achievable

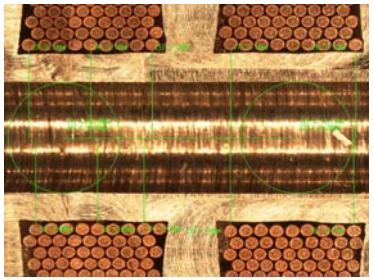
Effect of mechanical tolerances

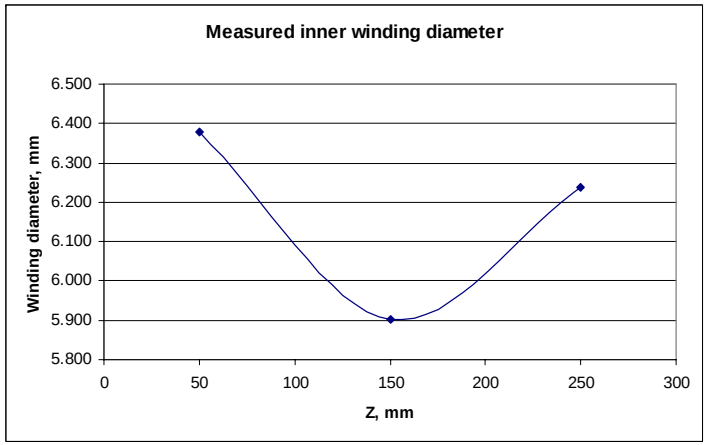


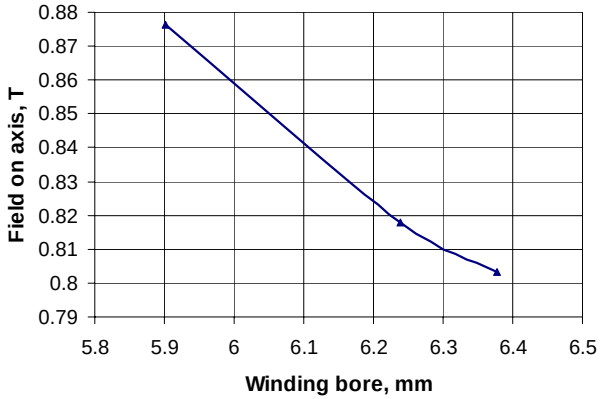
Prototype II results:

Field on axis varies by -2% for 100 μm increase in winding bore

→ +/- 1% variation in the field translates into +/- 50 μm precision in winding bore for pitch 14 mm







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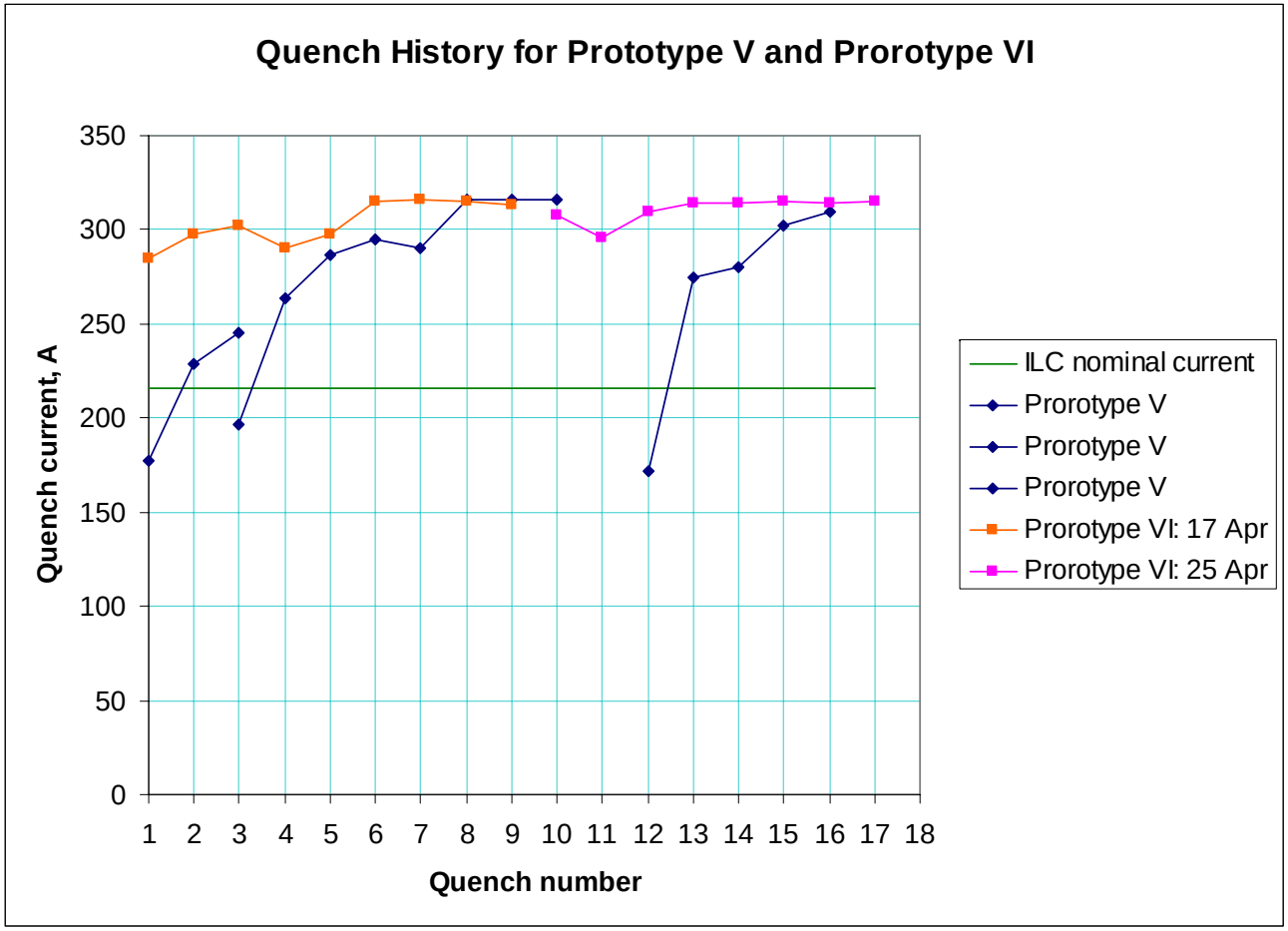
Undulator training and quenches



Prototype VI is re-wound and re-potted with improved technique Prototype V.

As a result of impregnation method improvement, the undulator shows practically no training with initial quench current much higher than a nominal current.

4-m undulator module

- Two 2-m long undulator sections (magnetic length is 1747 mm) in 4-m long cryostat
- Undulator sections can be powered separately.
- Undulator parameters:

  period 11.5 mm; design field 0.86 T; vacuum bore 5.23 mm
- Cold mass is cooled by a cryocooler

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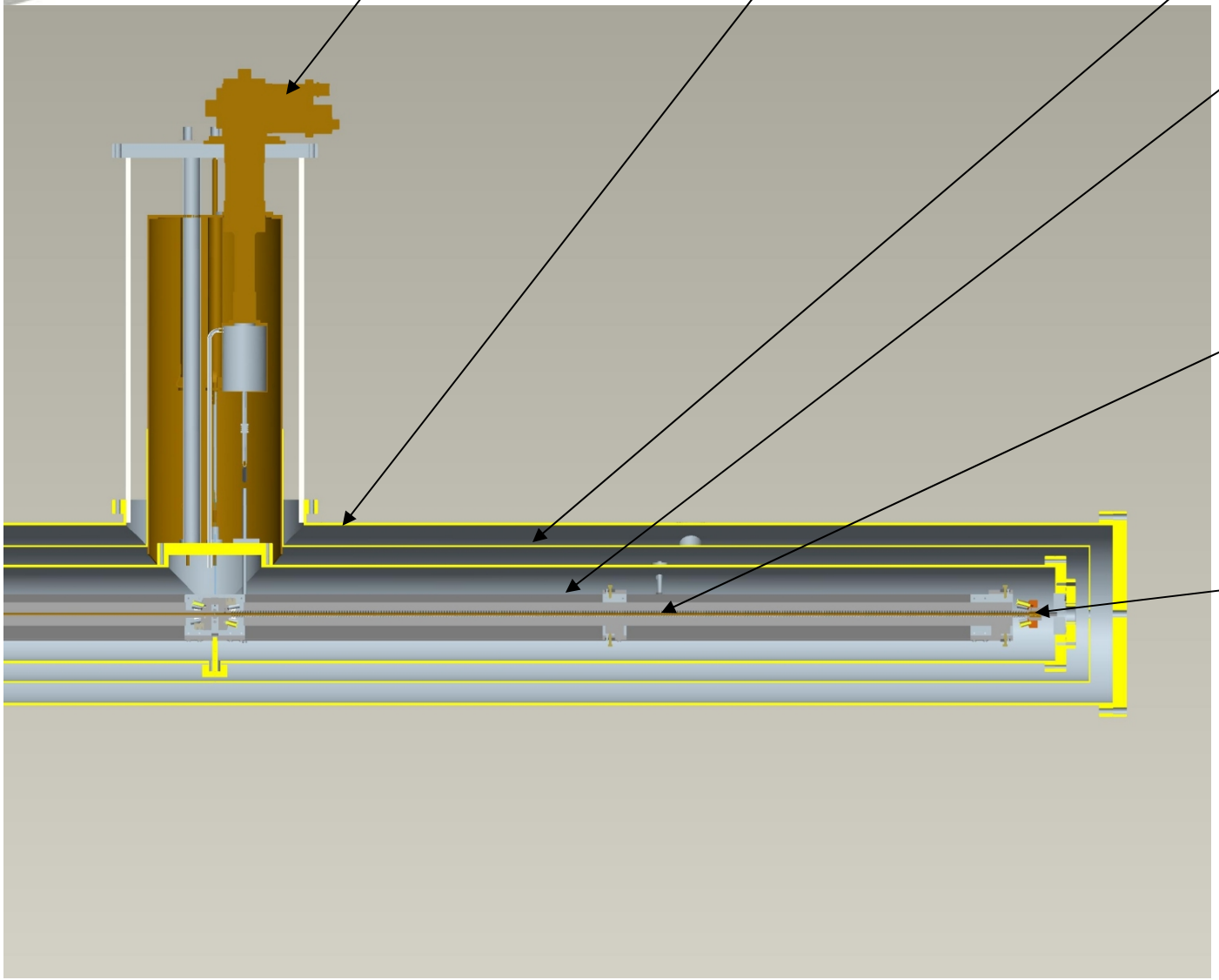
Design of 4-m long undulator module



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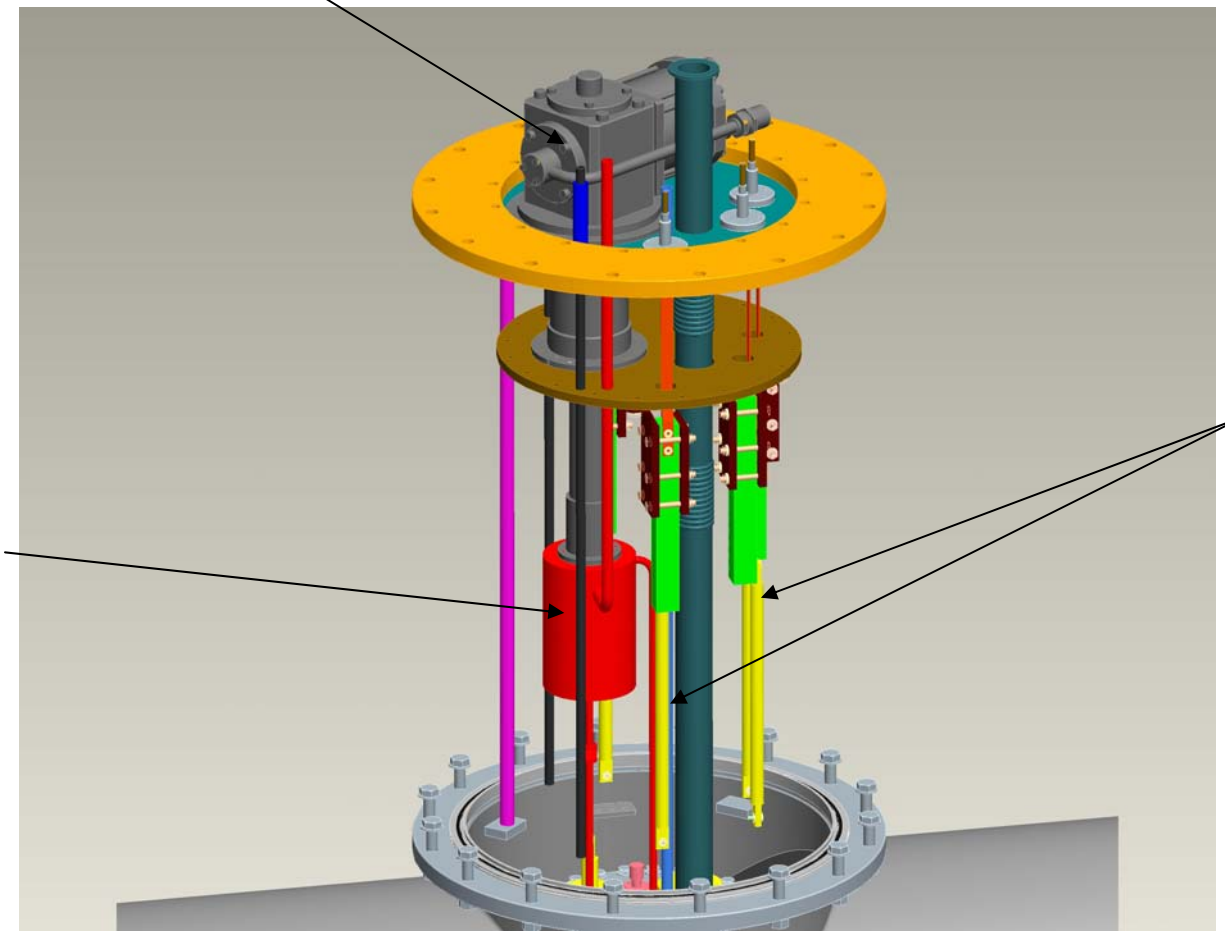
Design of undulator turret

Cryocooler



LHe condensing chamber

Two pairs of HTS leads

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2-m long undulator test facility

4-m undulator module status

- The detailed design is done (except turret).
- Cryostat vessel, LHe vessel are being manufactured; thermal shield is being ordered.
- Cold mass U-beam assembly is manufactured.
- Cryocooler, and HTS leads procured.
- First magnet section is wound and will be resin impregnated after completion of trial potting.
- The second former is being machined.
- The test facility is nearly ready for trial cool down.
- The first section is to be tested in October-November.
- The module to be completed by April 2008.

4-m undulator module future (discussion)

- Undulator module to be completed in spring 2008.
- Field profile will be measured for each 2-m long section but not for the complete undulator

-> ANL proposal to build a dedicated field measuring system seems to be vital.

- Undulator needs to be tested in a beam – How ? Where? When?

Summary

- RAL group is running a development programme on short-period superconducting helical undulator
- R&D phase of the programme is completed
- First 4-m long undulator module is being manufactured
- Future of this undulator to be defined